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Underutilized wild edible plants in the Chilga District, northwestern Ethiopia: focus on wild woody plants

Mekuanent Tebkew^{1*}, Zebene Asfaw² and Solomon Zewudie³

Abstract

Background: Ethiopia encompasses an extraordinary number of ecological zones and plant diversity. However, the diversity of plants is highly threatened due to lack of institutional capacity, population pressure, land degradation and deforestation. An adequate documentation of these plants also has not been conducted. The farmers in Ethiopia face serious and growing food insecurity caused by drought, land degradation and climate change. Thus, rural communities are dependent on underutilized wild edible plants to meet their food and nutritional needs. Hence, this study was conducted to examine the distribution, diversity, role, management condition and associated traditional knowledge of underutilized wild edible plants with a focus on woody plants in the Chilga District, northwestern Ethiopia.

Methods: A questionnaire survey, semi-structured interviews, preference and direct matrix rankings, a market survey and focused group discussion methods were employed for data collection. Data were collected from 96 respondents. A plant inventory was also conducted on 144 quadrates in two agroecologies and in three uses. Both quantitative and qualitative data analysis methods were used. Statistical Analysis System (SAS) version 9.0 was used for statistical analysis. Analysis of Variance ($P < 0.05$) was used to compare diversity indices and species richness between agroecologies and among kebeles.

Results: Thirty-three underutilized wild edible plants were recorded in the study area. Of the recorded plants, 45% were trees. Fruits (76%) were the most frequently used plant parts. More than half of the respondents (56.3% in the midland and 66.7% in the lowland area) consumed underutilized wild edible plants for supplementing staple food. Underutilized wild edible plant citation of the poor was significantly higher ($P < 0.05$) than medium and rich classes. Underutilized wild edible plants in the study area were threatened by agricultural expansion, overharvesting for fuel wood and construction, and by overgrazing. However, these plants have been given minimum conservation attention.

Conclusions: Thirty-three underutilized wild edible plants were recorded in the study area. The community consumes underutilized wild edible plants for supplementing staple food, filling food gaps and for recreation. The local community applies only some management practices to some wild edible plants. Therefore, special management is needed to sustain the benefits of these plants.

Keywords: farmlands, herbaceous species, natural forest, riverine forests, woody species

* Correspondence: mekuannttebkew@yahoo.com

¹Department of Natural Resource Management, University of Gondar,
P.O. Box 196, Gondar, Ethiopia

Full list of author information is available at the end of the article

Introduction

Nearly 40,000 to 100,000 plant species have been regularly used for food, shelter and medicines in the world [1]. However, only a small number of plants are widely used. The remaining plant diversity is underutilized [1,2]. Underutilized plants contribute immensely to family food security and serve as means of survival during times of drought, famine, shocks and risks [3]. They can also supplement nutritional requirements due to their better nutritional value [4,5].

Ethiopia encompasses an extraordinary number of ecological zones [6] and plant flora [3,7-9]. Currently, however, the biodiversity of Ethiopia faces various threats. The main threats are government institutional capacity, population growth, land degradation, deforestation and weak management [6,10]. Similarly, in the northwestern region of Ethiopia, which is endowed with sub-humid, dry and lowland areas, plenty of wild and semi-wild edible plants are present. However, the diversity of underutilized wild edible woody plants is not well known.

The lives of farmers in Ethiopia face several challenges including deforestation, drought, land degradation, and climate change [11], all of which contribute to serious food insecurity among households [12]. Thus, in most cases, rural communities depend on underutilized edible plants [13] due to their easily accessibility [5]. Understanding underutilized wild edible woody plants (UWEP) along with their threats forms a base for local decision-making and helps with the application of appropriate management. In addition, it assists us with the selection of a species that can adapt in different land use systems. Nevertheless, little documentation has been conducted in Ethiopia (that is, only 5% of Ethiopian districts have been studied) [13]. Moreover, information is lacking on the ecological distribution and potential of UWEPs for agroforestry practices and for maintaining food security in other districts of Ethiopia including the Chilga district.

The term 'underutilized wild edible plants' in this study refers to all wild edible plants (a) that are locally abundant, but globally rare; (b) that are undervalued, that is, their current public and private value is below its potential; and (c) for which there is a lack of research and information. Therefore, this study will (1) identify the distribution and quantify the diversity of UWEPs in different land uses, kebeles and agroecologies; (2) determine the role of UWEPs in livelihood diversification; (3) document the knowledge associated with utilization and management of UWEPs; and (4) identify the factors that threaten future uses and conservations of UWEPs in the Chilga District.

Materials and methods

Site description

The study was conducted in the Chilga district, North Gondar Zone of the Amhara Regional State. The Chilga

District is located 12°55" N and 37°06" E (Figure 1). It comprises 43 administrative kebeles (KA), which are the lowest administrative units next to districts. The altitude of the district ranges from 900 to 2,267 meters above sea level (m.a.s.l.) There are two agroecologies: midland (1,500 to 2,267 m.a.s.l) and lowland (900 to 1,500 m.a.s.l). About 33% of the area in the district is midland, while 67% is lowland agroecology. There are rivers and streams traversing the district, and these often serve as sources of water for the population (CDOA, 2012). The major soil covers of the Chilga district are 45% Cambisols, 40% Vertisols, and 15% Nitosols [14]. The natural vegetation of Chilga is mainly composed of various lowland and midland species [14]. The temperature of the district ranges from 11 to 32°C with a mean annual rainfall between 995 to 1,175 mm. It had a total population of 241,712 and a total area of 3,181 km². The livelihood of the local people mainly based on subsistence mixed agriculture (crop-livestock production).

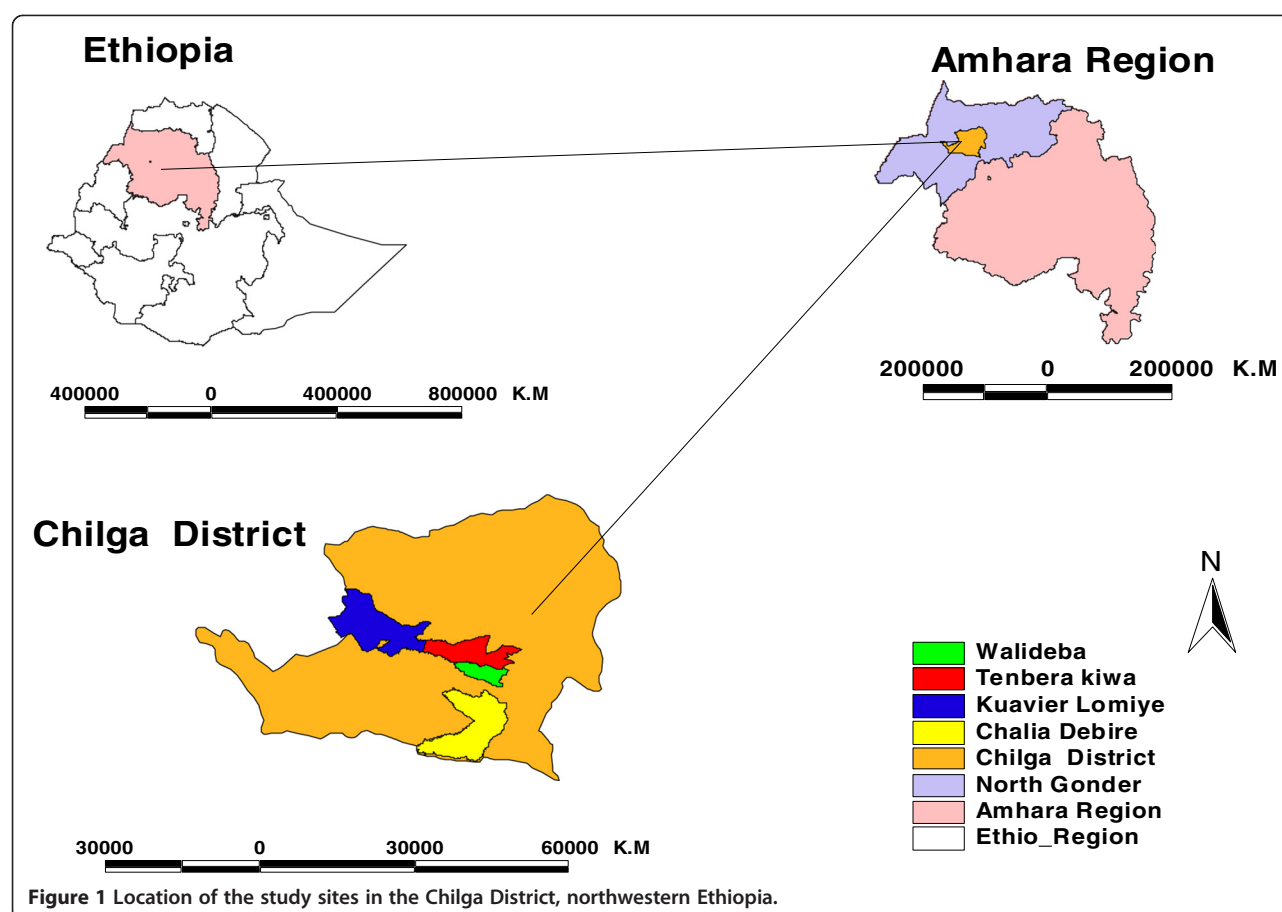
Selection of study sites

The study was conducted in four kebeles of the Chilga District from 8 October to 20 December 2012. District and kebele experts were contacted for general information. In addition, secondary archived materials were reviewed from CDOA to get further information.

The district contains midland and lowland agroecologies that are classified based on altitude, annual rainfall and temperature differences. Moreover, the sociodemographic and biophysical characteristics of the two agroecologies are not the same. Thus, based on accessibility for data collection and availability of UWEPs, two KAs from each agroecology and two villages from each KA were selected (see Table 1).

Selection of key informants and households

For this study, key informants (KI) are defined as knowledgeable persons about underutilized wild edible woody plants and local conditions. After selecting two villages at each KA, 24 KI (three from each village) were selected by using a snowball method to collect preliminary data and for questionnaire development following the method of Bernard [15]. Three farmers were randomly asked to call five knowledgeable persons in the village. Then, the three most knowledgeable KI were selected out of fifteen KI in each village with a total of 24 KI being selected from the study villages. Then, semi-structured interviews and questionnaires were prepared to interview the KI and household (HH), respectively. A simple stratification of HHs was conducted by age (≤ 40 and > 40) and wealth (poor, medium and rich), which were commonly used in assessing the local knowledge and plant utilization [16]. Hence, 12 HH classified by age category (≤ 40 and > 40 in 1:1 ratio) and wealth (4 HH for each wealth class) were taken in



each study village (Table 2). Thus, 96 HHs (78 males and 18 females) from four KA (24 HHs from each) were interviewed for the whole study, thereby constituting 5% of the population.

Data collection

Questionnaire survey and key informant interview

Questionnaires and semistructured interviews were prepared, pretested and administered to HHs and KIs,

respectively (16, 17). All interviewees were met on a 'one-to-one' basis and asked the same standard (open and closed-ended) questions using the local language (Amharic) based on their consent, including expansions or clarifications as needed. Consent was given by the informants to the district agricultural office. Information including vernacular names, parts used and consumption role of the plants was gathered. In addition, traditional management practices, other uses, and threats of UWEPs were also recorded.

Table 1 Sampled kebeles, villages, households and altitude in the Chilga District, northwestern Ethiopia

| Study kebeles | Sampled villages | Number of respondents | Altitude (m.a.s.l.) |
|-------------------------|------------------|-----------------------|---------------------|
| Quavier Lomiye (N = 24) | Achera | 12 | Below 1,500 |
| | Bele Wuha | 12 | |
| Tenbera Kiwa (N = 24) | Gint | 12 | Below 1,500 |
| | Kilel | 12 | |
| Walideba (N = 24) | Bete Skangie | 12 | Above 1,500 |
| | Mehalgie | 12 | |
| Chalia Debire (N = 24) | Ateraho | 12 | Above 1,500 |
| | Awugiber | 12 | |

Field observation and focused group discussion

Repeated field observations were conducted in the study sites by walking transects where most of the UWEPs are grown/cultivated. The purpose of the field observation was to obtain actual information of presence, growth habit, habitat characteristics and identification of edible plant species mentioned during the interviews. A focused group discussion of KI was conducted at each study site to verify the data and identification of underutilized edible plants. All underutilized wild edible plants listed in the socioeconomic survey were verified and idiosyncratic ideas were removed from the data.

Table 2 Importance value index (IVI) of the top ten woody species in three land uses and two agroecologies in Chilga District, northwestern Ethiopia

| Scientific name | LLA | | | MLA | | | Average |
|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | NF | R | FL | NF | R | FL | |
| <i>Anogeissus leiocarpa</i> | 39.88^b | 39.51^b | 17.25 | 32.80^a | 16.66^c | 13.68 | 26.63^a |
| <i>Syzygium guineense</i> | - | 0.95 | - | 28.72^b | 86.63^a | 32.99^c | 24.88^b |
| <i>Focus sycomorus</i> | 22.73 | 8.19 | 15.01 | 7.92 | 7.72 | 42.22^b | 17.30 |
| <i>Diospyros abyssinica</i> | 3.22 | 80.93^a | 8.81 | 2.11 | 8.41 | 1.07 | 17.31 |
| <i>Flueggea virosa</i> | 35.80^c | 12.85 | 32.31^b | 3.74 | - | 1.03 | 14.29 |
| <i>Terminalia laxiflora</i> | 42.26^a | 1.77 | 25.94^c | 8.71 | 1.77 | 5.10 | 13.96 |
| <i>Croton macrostachys</i> | - | - | 4.91 | 18.00^c | 11.13 | 47.83^a | 13.64 |
| <i>Maytenus arbutifolia</i> | 2.28 | 13.27 | 1.41 | 14.48 | 23.94^b | 25.86 | 13.54 |
| <i>Acacia polyachanta</i> | 21.56 | 15.31 | 39.45^a | - | - | - | 12.72 |
| <i>Acalypha</i> sp. | 1.51 | 21.84^c | - | 13.06 | 3.83 | 3.19 | 7.24 |
| Others | 130.76 | 105.38 | 154.91 | 170.46 | 139.91 | 127.03 | 138.49 |

LLA, lowland agroecology; MLA, midland agroecology; NF, natural forest; R, riverine forest; FL, farmland; Bold numbers with superscripts of a, b and c in each column are top three IVI values from highest to lowest order.

Direct matrix ranking

Direct matrix ranking was used to compare selected multipurpose species based on service categories. A direct matrix ranking method was exercised for commonly reported multipurpose UWEPS to assess their relative importance to local people and the extent of the existing threats related to their use values following the method of [16,17]. Six KI from each agroecology were selected and asked to assign a use value (5 to 0) for seven species in the lowland agroecology and for five species in the midland agroecology. The frequency of citation as multipurpose species was used for ranking UWEPS. Use categories for the comparison included construction, medicine, fruit/food, fuel wood, shade, farm and household implements, and fences, as used in the work of Cotton (16) and Martin (17).

Preference ranking

Preference ranking of selected UWEPS was conducted using taste and use criteria for each study kebele to assess the perception of the community. The most preferred underutilized wild edible plants in each study kebele were selected by KIs, and ranking (4-most preferred, 3-commonly preferred, 2-preferred but not so common, and 1-occasionally used) was conducted by all respondents, who followed the method of Jain et al. [17]. Similarly ranking of conservation demand for selected underutilized wild edible plants was conducted to assess conservation status of most preferred species following the method of Jain et al. [18] (4-for the species whose conservation is highly demanded, 3-conservation urgently demanded, 2-conservation required but not so urgent, and 1-conservation not required at present). Finally, such

ranking of the species was summed up, and average ranking was employed at the site level.

Threats to underutilized edible

The major human and natural factors that possibly threaten the survival of underutilized wild edible plants were identified through preliminary assessment. Thus, based on the relative importance of the threatening factors, priority ranking was conducted by eight KIs using the method of [16]. One to five scores were assigned where one was for the least while five was for the most destructive threat. Then, all ranks were summed up, and total ranking was conducted to determine the main threats.

Market survey

Assessments of Gint, Negadie Bahire, and Chandeba local markets (nearest market places to the study sites) were conducted to judge market prices of the recorded underutilized edible plants.

Plant identification

All encountered plants were identified and recorded by their vernacular names. Later, these were converted to their botanical names using *Flora of Ethiopia and Eritrea* [19-25] and experience. Plant specimens were collected and taken to the National Herbarium of Addis Ababa University for plant identification of plants that were not identified in the field.

Vegetation inventory Field inventory of all UWEPS (woody) was employed with key informants to obtain information on the type of plants and their species diversity.

To conduct this, the selected study villages were stratified into three land uses (forms), that is, (1) natural forest (NF), (2) farmland (FL), and (3) riverine forests (R). Then, representative populations in each land use/form were selected. Six quadrates were laid in each land use per village following two transects running parallel along the

gradient. The two transect lines were 200 m apart and quadrates along the transect lines were also 200 m apart both in the natural forest and farmland. For riverine areas, two transect lines were established for each village following the water flow and three quadrates were taken at 200-m intervals from each transect line. The first quadrate

Table 3 List of all underutilized edible plants encountered in the Chilga District, northwestern Ethiopia

| Scientific name (Family) | Vernacular name (Amh) | Habit | Habitat | Added values | PU | MD | Voucher number |
|--|-----------------------|-------|---------|-------------------------|----|----|----------------|
| <i>Acanthus sennii</i> Chiov. (Acanthaceae) | Kushashile | SH | BN, N,R | FE, FU, | FL | F | MT-001 |
| <i>Balanites aegyptiaca</i> (L.) . (Balanitaceae) | Kudekuda | T | N,R,F | FE, FU,SC, | F | F | MT-002 |
| <i>Boletus edulis</i> Bull. Ex Fries. (Bolentaceae) | Enguday | H | F, N | - | ST | P | MT-003 |
| <i>Carissa Spinarum</i> L. (Apocynaceae) | Agam | SH | N,R, | FE, M, FU, FT | F | F | MT-004 |
| <i>Corchorus olitorius</i> L. (Tiliaceae) | Kudra | H | F | FD, Rope | L | P | MT-005 |
| <i>Cordia africana</i> L. (Boraginaceae) | Wanza | T | H | T,FU, FE, FU, SH, FD, M | F | F | MT-006 |
| <i>Dichrostachys cinerea</i> Wight & Am (Fabaceae) | andera | S/ T | N | - | F | F | MT-007 |
| <i>Dioscorea prahensis</i> Benth (Dioscoreaceae) | Senssa | C | N,R | - | R | P | MT-008 |
| <i>Diospyros abyssinica</i> (Hiem) F. Wite (Ebenaceae) | Serkin | T | F,R | FU,T,CO,SH, FE, | F | F | MT-009 |
| <i>Diospyros mesiliformis</i> Hochst ex.A.DC. (Ebenaceae) | Gurmacha | T | F,R | T,FU,SH,CO,FE,SC | F | F | MT-010 |
| <i>Dovyalis abyssinica</i> (A. Rich.) Warburg. (Flacourtiaceae) | Koshim | T | N,R | FU, FE, | F | F | MT-011 |
| <i>Ficus sur</i> Forssk. (Moraceae) | Shola | T | R,F,N | CO,FE,SC,SH,FU | F | F | MT-012 |
| <i>Ficus sycomorus</i> L. (Moraceae) | Bamba | T | F,N,R,H | CO,FE,SC,FD,SH, HB | F | F | MT-013 |
| <i>Ficus vallis-choudae</i> Del. (Moraceae) | Bambula | T | N | FU, FE | F | F | MT-014 |
| <i>Ficus vasta</i> Forssk. (Moraceae) | Warka | T | N,R,F,H | FU, CO, FE, SC, | F | F | MT-015 |
| <i>Flueggea virosa</i> Guill. & Perr. (Euphorbiaceae) | Shasha | SH | F,N,R | FE, FU,CO,FU | F | F | MT-016 |
| <i>Gardenia ternifolia</i> Schumach and Thonn. (Rubiaceae) | Gambilo | S/T | F,N,R | FD, FU, | F | F | MT-017 |
| <i>Gloriosa superba</i> (Liliaceae) | Yemariam twa | H/sh | F | FD, WASHING | F | F | MT-018 |
| <i>Hibiscus cannabinus</i> L. (Malvaceae) | Yeberha Wayika | H | F | FD | F | D | MT-019 |
| <i>Hibiscus esculentus</i> L. (Malvaceae) | Wayika | H | F | M, FD, | L | | MT-020 |
| <i>Maytenus senegalensis</i> Forssk (Celastraceae) | Koshikosh | T | N,F,R | FE,FT, | F | F | MT-021 |
| <i>Mimusops kummel</i> Bruce ex A.DC. (Sapotaceae) | Ishe | T | R,F | FE,FU,HB,CO, | F | F | MT-022 |
| <i>Morusmeso zygia</i> (Moraceae) | Injori | C | N, R | - | F | F | MT-023 |
| <i>Pittosporum viridiflorum</i> Sims. (Pittosporaceae) | Dengay Seber | S | N,F, R | FU | F | F | MT-024 |
| <i>Rhus glutinosa</i> A. Rich. subsp. <i>Abyssinica</i> (Oliv.) M. Gilnert (Anacardiaceae) | Qamo | S | N, R | Fe, FU | F | F | MT-025 |
| <i>Rosa abyssinica</i> Lindley (Rosaceae) | Qega | SH | N | FE,FU, | F | F | MT-026 |
| <i>Saba comorensis</i> (Bo.) Pichon (Apocynaceae) | Ashama | C | R | CO, SH, | F | F | MT-027 |
| <i>Sporobolus africanus</i> (Poir) Robyns and Tournay (Poaceae) | Muriye | H | N,FLD,R | FD | S | D | MT-028 |
| <i>Syzygium guineense</i> (Willd.) DC. (Myrtaceae) | Dokima | T | R,F | M, FE, FU, SH, CO | F | F | MT-019 |
| <i>Tamarindus indica</i> L. (Fabaceae) | Kumer | T | R,N,F | FE,FU,CO,SC | S | D | MT-030 |
| <i>Ximenia americana</i> L. (Olacaceae) | Enkoye | Sh | N | FU,M | F | F | MT-031 |
| <i>Ziziphus abyssinica</i> Hoschst. (Rhamnaceae) | Abetere | T | F,N,R, | Fu,Fe | F | F | MT-032 |
| <i>Ziziphus spina-christi</i> Willd. (Rhamnaceae) | Arka | S/T | N | Fe,Fu, co,Fd,sc | F | F | MT-033 |

Key to abbreviations: **Habit:** Sh, shrub; T, tree; H, herb; C, climber; **Habitat:** N, natural forest; F, farmland; R, riverine and valley; H, home garden; Fld, field. BN, boundary; **Added value:** Fu, fuel wood; CH, charcoal; M, medicinal; CO, construction; Fe, fencing; SC, soil and water conservation; FD, fodder; Sh, shade; HB, production; T, timber; FT, farm and household tools. **PU (Parts used):** F, fruit; R, root; Fl, flower nectar; S, seed; W, whole part. **Mode of utilization (MD):** F, fresh; P, prepared/cooked; D, dried and prepared.

in each land use was laid out randomly from the east of the sampled population. The quadrature sizes for natural forest and riverine forest was 20 m × 20 m (400 m²) for trees (main plot), 10 m × 10 m for shrubs and saplings at the center of main plot, and 1 m × 1 m for herbs and seedlings with an 'X' design that followed the method of [26,27]. For farmland, a quadrature size of 50 m × 40 m (main plot) for trees, 25 m × 20 m for saplings and shrubs, and five 2 m × 2 m in an 'X' design for seedlings and herbs was taken.

In the smallest subplots (1 m²) or 4 m², all herbs and seedlings were identified and counted (including all plants less than 50 cm in height). In the subplots of 10 m × 10 m or 25 m × 20 m, diameter at breast height (DBH) of all saplings and shrubs (DBH <10 cm) was measured with a caliper. The DBH of trees (DBH ≥10 cm) were measured in the entire plot area. Trees forked below breast height were measured independently and average DBH was taken. One hundred forty-four main quadrates were taken for the whole study.

Data analysis

Both quantitative and qualitative data analyses were conducted after the necessary data collection. Statistical Analysis System (SAS) 9.0 version software was used for descriptive and statistical analysis. Descriptive analyses (informant consensus, direct matrix ranking and preference ranking) were presented in the form of percentages, figures and means. An analysis of variance (ANOVA) of diversity indices (Shannon Weiner diversity index, Simpson's diversity index and evenness), species richness and wealth classes was conducted to compare diversity between agroecologies and among kebeles. A T test mean separation ($P < 0.05$) of diversity indices and wealth classes was conducted using least significance difference (LSD). The Spearman Rank Correlation test was also employed to evaluate whether there is significant ($P < 0.05$) correlation between age and UWEs list.

Species richness

It is defined as the number of species per quadrature, area or community. In this particular case, the numbers of observed species across the whole sample quadrates of each land use in each agroecology and Kebele were used as a representation of species richness. However, quadrature species richness is used as a comparison of species richness between agroecologies and kebeles.

Shannon diversity index (H')

It is very important when comparing diversity among samples and habitats to use an index that is more sensitive to richness. The value of H' is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 [28,29].

Therefore, the species diversity of the midland and lowland agroecologies was estimated as follows:

$$H' = -\sum_{i=1}^s P_i \ln p_i \quad (1)$$

where H' = is Shannon diversity and P_i = proportion of individual species.

Simpson's diversity index

Simpson's diversity index is the most widely used method for estimating the richness diversity of community and is used to compare different communities or habitats [29]. The Simpson diversity is less sensitive to richness and more sensitive to evenness. The Simpson's diversity is calculated as follows:

$$D = 1 - \sum_{i=1}^s P_i^2 \quad (2)$$

Evenness

It is a widely used and understood method for estimating evenness of the communities [30]. The most commonly used index of estimating evenness diversity is the Pielou index, which is determined as follows:

$$J' = H' / H'_{\max} \quad (3)$$

where J' = Pielou evenness index; H' = the observed value of Shannon index; $H'_{\max} = \ln S$, and S = total number of species.

Importance value index and relative frequency

Estimation of the importance value index (IVI), abundance, frequency and relative frequency was conducted to assess the importance of each species to the survey sites using the method of [31] and [32] and these estimates are determined with the following:

$$IVI = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Dominance} \quad (4)$$

Table 4 Underutilized woody edible plants species diversity for three land uses in lowland agroecology (LLA) and midland agroecology (MLA) of the study area, northwestern Ethiopia

| Agroecology | Species richness | Simpson_1-D | Shannon | Evenness |
|-------------|------------------|-------------|---------|----------|
| Lowland | | | | |
| NF | 14 | 0.69 | 1.73 | 0.66 |
| R | 14 | 0.79 | 1.93 | 0.73 |
| FL | 12 | 0.76 | 1.78 | 0.71 |
| Midland | | | | |
| NF | 12 | 0.78 | 1.77 | 0.71 |
| R | 14 | 0.79 | 2.05 | 0.78 |
| FL | 12 | 0.82 | 1.92 | 0.77 |

NF, natural forest; R, riverine forest; FL, farmland.

Table 5 Underutilized woody edible plants species diversity for three land uses in the study sites, northwestern Ethiopia

| Study sites | Species richness | | | Simpson_1-D | | | Shannon _H | | | Evenness | | |
|----------------|------------------|----|----|-------------|------|------|------------|------|------|----------|------|------|
| | NF | R | FL | NF | R | FL | N | R | FL | NF | R | FL |
| Quavere Lomiye | 10 | 13 | 6 | 0.74 | 0.8 | 0.67 | 1.7 | 1.95 | 1.33 | 0.74 | 0.76 | 0.74 |
| Tenbera | 12 | 7 | 11 | 0.63 | 0.73 | 0.7 | 1.55 | 1.55 | 1.67 | 0.62 | 0.8 | 0.7 |
| Walideba | 12 | 13 | 10 | 0.76 | 0.88 | 0.76 | 1.78 | 2.34 | 1.72 | 0.71 | 0.91 | 0.75 |
| Chalia Debire | 7 | 10 | 4 | 0.67 | 0.66 | 0.6 | 1.37 | 1.57 | 1.05 | 0.7 | 0.68 | 0.76 |

LLA, lowland agroecology; MLA, midland agroecology; NF, natural forest; R, riverine forest; FL, farmland.

$$\text{Frequency} = \text{number of occurrence of a given species in the plots studied} \quad (5)$$

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of any species}}{\text{Total frequency of all species}} * 100 \quad (6)$$

$$\text{Relative Density (\%)} = \frac{\text{Number of individual of each species per ha}}{\text{Total number of individuals of all species per ha}} * 100 \quad (7)$$

$$\text{Relative Dominance (\%)} = \frac{\text{Basal area of each species}}{\text{Total basal area of all species}} * 100 \quad (8)$$

$$\text{Basal area} = \frac{\sum D^2}{4}, \text{ D = Diameter of trees at breast height} \quad (9)$$

Results

Importance value index

The importance value index (IVI) of woody species is dominated by four species (86.12%), namely *Anogeissus leiocarpa*, *Syzygium guineense*, *Diospyros abyssinica* and *Ficus sycomorus* (Table 2 and Additional file 1). The species distribution varies in land uses and in agroecologies. In the lowlands (LLA), *Terminalia laxiflora*, *Diospyros abyssinica* and *Acacia polyachanta* are the top ranking species for NF, riverine and FL, respectively. *Anogeissus leiocarpa*, *Syzygium guineense* and *Ficus sycomorus* are also the first ranked species in the midland (MLA) for NF, riverine and FL land uses, respectively. Some of the woody plants in the study area were habitat specific. For example, *Syzygium guineense* was recorded only from riverine land use of the LLA.

Diversity of underutilized wild edible plants

Thirty-three UWEPS (28 woody and five herbaceous) species were recorded in the study area (Table 3). The family Moraceae had five species; the families Malvaceae, Fabaceae, and Euphorbiaceae had two species each; and the remaining families had one species each.

Table 6 Means (±std) of woody underutilized edible plant diversity for the three land uses in the study area, northwestern Ethiopia

| Diversity indices | Agroecology | NF | R | FL |
|-------------------|---------------|--------------------------|--------------------------|--------------------------|
| Richness | MLA | 2.87 ^a ± 0.29 | 3.71 ^a ± 0.38 | 2.00 ^a ± 0.22 |
| | LLA | 3.42 ^a ± 0.22 | 3.17 ^a ± 0.35 | 1.87 ^a ± 0.33 |
| | Over all mean | 3.15 ± 0.18 | 3.44 ± 0.26 | 1.93 ± 0.19 |
| Simpson | MLA | 0.44 ^a ± 0.05 | 0.55 ^a ± 0.04 | 0.31 ^a ± 0.05 |
| | LLA | 0.55 ^a ± 0.03 | 0.46 ^a ± 0.06 | 0.27 ^a ± 0.06 |
| | Overall mean | 0.49 ± 0.03 | 0.51 ± 0.03 | 0.29 ± 0.04 |
| Shannon | MLA | 0.77 ^a ± 0.09 | 1.02 ^a ± 0.09 | 0.51 ^a ± 0.09 |
| | LLA | 0.97 ^a ± 0.07 | 0.85 ^a ± 0.12 | 0.46 ^a ± 0.11 |
| | Overall mean | 0.87 ± 0.06 | 0.93 ± 0.08 | 0.48 ± 0.07 |
| Evenness | MLA | 0.68 ^b ± 0.06 | 0.80 ^a ± 0.06 | 0.50 ^a ± 0.06 |
| | LLA | 0.82 ^a ± 0.03 | 0.66 ^a ± 0.08 | 0.43 ^a ± 0.09 |
| | Overall mean | 0.75 ± 0.03 | 0.73 ± 0.05 | 0.56 ± 0.09 |

^{a,b}Means with the same letter ordered vertically within each diversity parameter are not significant ($P < 0.05$).
FL, farmland; LLA, lowland agroecology; MLA, midland agroecology; NF, natural forest; R, riverine forest.

Table 7 Mean (\pm std) of underutilized woody wild edible plant diversity for the three land uses in lowland agroecology (LLA) of the Chilga District, northwestern Ethiopia

| Diversity indices | Kebeles | NF | R | FL |
|-------------------|----------------|------------------------------|------------------------------|------------------------------|
| Richness | Quavere Lomiye | 3.08 ^a \pm 0.31 | 4.25 ^a \pm 0.43 | 1.92 ^a \pm 0.29 |
| | Tenbera | 3.75 ^a \pm 0.30 | 2.08 ^b \pm 0.34 | 1.83 ^a \pm 0.61 |
| | Overall mean | 3.42 \pm 0.22 | 3.17 \pm 0.35 | 1.87 \pm 0.33 |
| Simpson | Quavere Lomiye | 0.52 ^a \pm 0.06 | 0.59 ^a \pm 0.06 | 0.34 ^a \pm 0.07 |
| | Tenbera | 0.57 ^a \pm 0.05 | 0.34 ^b \pm 0.09 | 0.19 ^a \pm 0.09 |
| | Overall mean | 0.55 \pm 0.03 | 0.46 \pm 0.06 | 0.27 \pm 0.06 |
| Shannon | Quavere Lomiye | 0.90 ^a \pm 0.10 | 1.15 ^a \pm 0.13 | 0.53 ^a \pm 0.13 |
| | Tenbera | 1.05 ^a \pm 0.09 | 0.55 ^b \pm 0.16 | 0.39 ^a \pm 0.18 |
| | Overall mean | 0.98 \pm 0.07 | 0.85 \pm 0.12 | 0.46 \pm 0.11 |
| Evenness | Quavere Lomiye | 0.83 ^a \pm 0.04 | 0.78 ^a \pm 0.07 | 0.59 ^a \pm 0.13 |
| | Tenbera | 0.82 ^a \pm 0.05 | 0.55 ^a \pm 0.14 | 0.27 ^a \pm 0.12 |
| | Overall mean | 0.82 \pm 0.03 | 0.66 \pm 0.08 | 0.43 \pm 0.09 |

^{a,b}Means with the same letter ordered vertically within each diversity parameter are not significant ($P < 0.05$).
FL, farmland; NF, natural forest; R, riverine forest.

Species richness of underutilized wild edible woody plants (UWEPs) recorded in the study area is presented in Tables 4 and 5. Overall, mean value difference in species richness and diversity indices of UWEPs in two agroecologies were in the order of: R > NF > FL (Table 6). Evenness in the LLA was significantly ($P < 0.05$) higher than MLA for NF land use. Comparison of diversity within each agroecology shows species richness of riverine land use at Quavere Lomiye Kebele was significantly higher than at Tenbera in the LLA (Table 7). Within the MLA, for NF land use, Simpson and evenness diversity indices of Chalia Debire Kebele were significantly higher

than Walideba Kebele Simpson and evenness diversity (Table 8).

Underutilized wild edible plants habits and parts used

Growth forms of UWEPs comprise trees, shrubs, herbs and climbers. Of all ($n = 33$) UWEPs, most (45%) were trees followed by shrubs (about 27.3%) (Figure 2a). Trees were also the dominant growth forms at each study site, representing about half at Walideba, Chalia Debire and Quabier Lomiye and 46.4% at Tenbera Kebele. The study also indicated that fruits were the most commonly

Table 8 Mean (\pm std) of woody wild edible species diversity for three land uses in midland agroecology (MLA) in northwestern Ethiopia

| Diversity Indices | Kebele | NF | R | FL |
|-------------------|---------------|-------------------------------|------------------------------|------------------------------|
| Richness | Walideba | 2.67 ^a \pm 0.56 | 3.08 ^a \pm 0.57 | 2.33 ^a \pm 0.38 |
| | Chalia Debire | 3.08 ^a \pm 0.19 | 4.33 ^a \pm 0.47 | 1.67 ^a \pm 0.19 |
| | Overall mean | 2.87 \pm 0.29 | 3.71 \pm 0.38 | 2.00 \pm 0.22 |
| Simpson | Walideba | 0.35 ^b \pm 0.078 | 0.52 ^a \pm 0.08 | 0.36 ^a \pm 0.08 |
| | Chalia Debire | 0.54 ^a \pm 0.03 | 0.58 ^a \pm 0.03 | 0.27 ^a \pm 0.07 |
| | Overall mean | 0.44 \pm 0.05 | 0.55 \pm 0.04 | 0.32 \pm 0.06 |
| Shannon | Walideba | 0.64 ^a \pm 0.15 | 0.92 ^a \pm 0.17 | 0.61 ^a \pm 0.15 |
| | Chalia Debire | 0.91 ^a \pm 0.06 | 1.11 ^a \pm 0.09 | 0.40 ^a \pm 0.11 |
| | Overall mean | 0.78 \pm 0.09 | 1.02 \pm 0.09 | 0.51 \pm 0.09 |
| Evenness | Walideba | 0.54 ^b \pm 0.10 | 0.79 ^a \pm 0.12 | 0.59 ^a \pm 0.13 |
| | Chalia Debire | 0.83 ^a \pm 0.04 | 0.82 ^a \pm 0.04 | 0.53 ^a \pm 0.14 |
| | Overall mean | 0.68 \pm 0.06 | 0.80 \pm 0.06 | 0.56 \pm 0.09 |

^{a,b}Means with the same letter ordered vertically within each diversity parameter are not significant ($P < 0.05$).
NF, natural forest; R, riverine forest; FL, farmland.

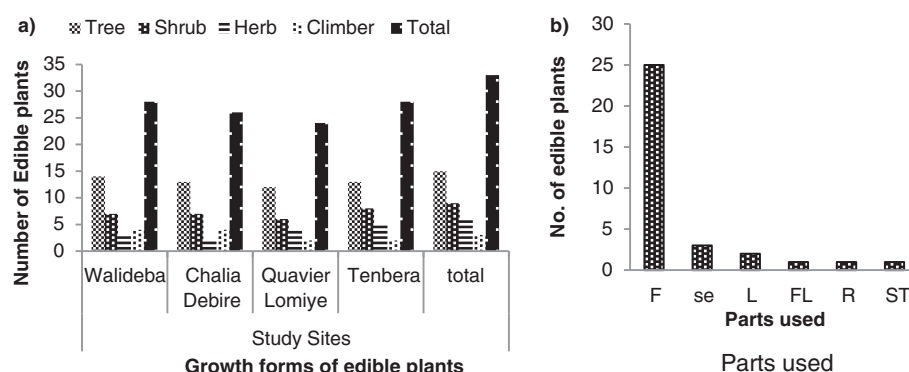


Figure 2 Growth forms and parts used for edible plants in the study area, northwestern Ethiopia. F, fruit; Se, seed; L, leaf; FL, flower nectar; R, root/ tuber; ST, stem bark.

used parts of UWEPs (76%), while flowers, roots, and stems were the least used parts (Figure 2b).

Utilization and role of underutilized wild edible plants

The results of this study showed that UWEPs play an important role in the household livelihood diversification, and these results are summarized below:

1. Diversity of uses.

UWEPs offer various uses such as fuel wood, fencing, construction, medicinal, fodder, timber, honey production and detergent (Figure 3). More than three-fourths of UWEPs in the study sites are used for fuel wood and fencing purposes. The community utilized these plants for various reasons (Table 9). About 56% and 33.3% of the respondents in MLA mentioned that UWEPs were used to supplement their staple foods and for refreshment, respectively. Also 21% of the respondents consume products to fill food gaps. In the LLA, 67% of the respondents mentioned that UWEPs were used in

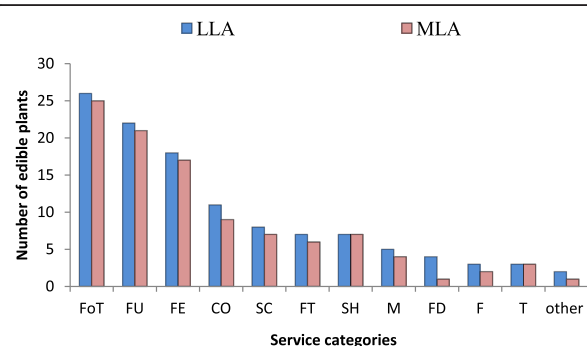


Figure 3 Use categories of underutilized edible plants in the Chilga District, northwestern Ethiopia. FoT, food and other uses; Fu, fuel wood; FE, fencing; CO, construction; SC, soil and water conservation; FT, farm and household tools; SH, shade; M, medicinal; FD, fodder; F, food only; T, timber.

times of normal diet. UWEP utilization by wealth class using the free-list exercise approach is shown in Table 10.

UWEP citation in the poor HHs was significantly higher ($P < 0.05$) than for medium and rich wealth classes in the Walideba and Chalia Debire kebeles. Similarly, UWEP citation in the poor HHs was significantly higher than for the richest groups in Quavier Lomiye Kebele. Plant citation in Tenbera Kebele was significantly different among wealth classes in the following order: poor > medium > rich.

2. Income generating role of underutilized wild edible plants.

UWEPs could generate income for HHs through either sales to domestic market or exporting to neighboring countries, mainly the Sudan (Table 11). Twelve marketable UWEPs were recorded with the mean unit price of products ranging from 0.63 to 5.6 ETB (Ethiopian Birr). Youngsters in the local market sell most of these marketable UWEPs (eight plants). Of the marketable UWEPs, *Tamarindus indica* and *Hibiscus cannabinus* were the most highly priced species. About 83% and 17% of the marketable UWEPs are marketed in the local markets and for export, respectively (Figure 4a). Of all marketable UWEPs, fruits represent the highest proportion of edible parts (about 75%) (Figure 4 b).

3. Direct matrix ranking for underutilized wild edible plants.

Seven UWEP species in the LLA and five in the MLA were selected, and direct matrix ranking was conducted based on the key informants' preferences of use category. Thus, food and fuel use categories were the first and second ranked categories, respectively, for the selected multipurpose species (Table 12) for lowland and (Table 13) for MLA. When overall categories were considered, species with top score ranking were ordered as follows:

Table 9 Consumption roles of underutilized wild edible plants in the study area, northwestern Ethiopia

| Agroecology | Supplemental | | Recreational | | Fill food gaps | | All | |
|-------------|--------------|------|--------------|------|----------------|------|------------|------|
| | Informants | % | Informants | % | Informants | % | Informants | % |
| MLA | 27 | 56.3 | 16 | 33.3 | 10 | 20.8 | 10 | 20.8 |
| LLA | 32 | 66.7 | 14 | 29.2 | 6 | 12.5 | 11 | 22.9 |

LLA, lowland agroecology; MLA, midland agroecology.

Diospyros mespiliformis > *Syzygium guineense* > *Tamarindus indica* for LLA; *Syzygium guineense* > *Diospyros abyssinica* > *Ximenia americana* for MLA. *Carissa spinarum* received the list score from both agroecologies.

Informant consensus and preference of underutilized wild edible plants

Species preference ranking of UWEs was conducted based on the informants' consensus approach to find out the relative importance of plants to the local community (Table 14). The most preferred species in decreasing order were *S. guineense*, *D. abyssinica*, *Carissa spinarum*, *Mimusops kummel*, *D. mespiliformis*, *Ximenia americana* and *Cordia africana*. However, species preference varies from kebele to kebele. *S. guineense*, *D. mespiliformis* and *M. kummel* were the most preferred edible plants, cited by 95.8% of respondents in Walideba Kebele. Similarly, *S. guineense* and *M. kummel* were the best species cited by all respondents in Chalia Debire Kebele. Again, *D. mespiliformis* was the preferred species in Quavier Lomiye and Tenbera kebeles (species cited by ≥ 29 informants of the total respondents).

Selection and ranking of the most preferred candidate UWEs, based on their taste and use, was conducted in each kebele. *S. guineense* is the most preferred species in Walideba and Chalia Debire kebeles (Figure 5 a and b), while *Saba comorensis* was the most preferred in Quavier Lomiye and Tenebera (Figure 5 c and d). In terms of conservation demand of species, *M. kummel* and *X. americana* were the most highly preferred ones in the MLA and LLA study sites, respectively.

Underutilized wild edible plant list exercise

With regard to list length for free plants, variation exists between age groups. Respondents younger than 40 years

of age cited more UWEs than older people did across the study kebeles (Figure 6a). The Spearman correlation test has also shown a significant negative correlation between age and UWEs list ($r = -0.326$, $P < 0.05$).

The local community gains knowledge about UWEs utilization, processing and management through experience (Figure 6b). However, the major acquisition/transfer method was from parents, friends and relatives, and neighbors in both agroecologies. Sources of knowledge or acquisitions for the majority of respondents (87.5%) in MLA and 73% in LLA were the parents.

Traditional management practices and threats of underutilized edible plants

The results of this study indicated that there was a lack of training to local community to improve management, conservation and utilization of UWEs (Table 15). More than 77% of the respondents in MLA and 87.5% in LLA indicated that training on conservation and utilization of UWEs was not given from any concerned body. This indicated that the local community utilizes, manages and conserves these plant resources only through experience and traditional knowledge.

Identification and preference ranking of the major threats of UWEs based on their destructive effects were conducted (Table 16). It confirmed that illegal charcoal production, fuel wood collection, construction, agricultural land expansion, overgrazing and fire were the dominant threats.

Local communities practice different traditional management, which includes planting around the home garden, pruning, pollarding, fencing, and preventing growth of the most important plants by local culture in both the LLA and MLA (Table 16). Of the management practices; fencing, pollarding and local culture are the dominant practices in the LLA. In similar fashion, planting around

Table 10 Mean (\pm std) of underutilized wild edible plants free-list exercise by wealth class in the study sites, northwestern Ethiopia

| Wealth category | Walideba (Mean \pm std) | Chalia Debire (Mean \pm std) | Quavier Lomiye (Mean \pm std) | Tenbera (Mean \pm std) |
|-----------------|-------------------------------|--------------------------------|---------------------------------|-------------------------------|
| Poor (n = 32) | 15.50 ^a \pm 2.14 | 14.25 ^a \pm 0.65 | 12.38 ^a \pm 1.19 | 14.13 ^a \pm 0.81 |
| Medium (n = 32) | 9.75 ^b \pm 0.70 | 9.75 ^b \pm 0.26 | 10.13 ^{ab} \pm 0.92 | 9.63 ^b \pm 0.73 |
| Rich (n = 32) | 7.75 ^b \pm 0.82 | 9.75 ^b \pm 0.80 | 8.25 ^b \pm 0.88 | 6.63 ^c \pm 0.98 |
| Over All (96) | 11.00 \pm 1.03 | 11.25 \pm 0.68 | 10.25 \pm 0.66 | 10.13 \pm 0.81 |

^{a,b}Means with different letters ordered vertically in each Kebele were significant ($P < 0.05$).

Table 11 List of marketable underutilized wild edible plants in the Chilga District, northwestern Ethiopia

| Species name | Parts marketed | Unit | Mean price ^a | Number of respondents | Seller group ^b | Market category | Rank |
|--------------------------------|----------------|---------|-------------------------|-----------------------|---------------------------|-----------------|------|
| <i>Carisa spinarum</i> | F | cup | 0.83 | 6 | younger | D | 10 |
| <i>Corchorus olitorius</i> | L | handful | 2.2 | 10 | all | D | 8 |
| <i>Diospyros mesiliformis</i> | F | cup | 0.91 | 46 | younger | D | 2 |
| <i>Diospyros abyssinica</i> | F | cup | 0.8 | 27 | younger's | D | 6 |
| <i>Ficus sur</i> | F | cup | 0.63 | 2 | younger | D | 12 |
| <i>Hibiscus cannabinus</i> | Se | cup | 4.33 | 3 | adult | Exp | 11 |
| <i>Mimusops Kummel</i> | F | cup | 1 | 45 | younger | D | 3 |
| <i>Saba comorensis</i> | F | number | 0.7 | 35 | all | D | 4 |
| <i>Syzygium guineense</i> | F | cup | 1 | 64 | younger's | D | 1 |
| <i>Tamarindus indica</i> | Se | kg | 5.6 | 21 | all | Exp | 7 |
| <i>Ximenia Americana</i> | F | cup | 0.95 | 33 | younger | D | 5 |
| <i>Ziziphus spina- christi</i> | F | cup | 0.7 | 9 | younger | D | 9 |

F, fruit; Se, seed; L, leaf; D, local market; Exp, exported to other countries; a, Ethiopian birr (ETB); b, local classification of below 18-years old as younger and from 18- to 30-years of age as adult; Ranks were given by number of respondents.

home gardens and backyards and pollarding were the major practices in the MLA.

Fuel wood and illegal charcoal production and construction were the main threats in the MLA, whereas agricultural expansion, fuel wood collection, and charcoal making were dominant threats in the LLA.

Discussion

Importance value index

The importance value index (IVI) of all woody species indicates the ecological importance of each species to the area. In addition, it indicates the types of plant species on which the rural community is more reliant. The four top ranked species according to IVI value (*A. leio-carpa*, *S. guineense*, *F. sycomorus* and *D. abyssinica*) in the whole area were the most important UWEs. The high IVI of these species is probably due to their ability to produce a high number of seeds and maintain a persistent soil seed bank. There was variation in IVI in agroecology and land uses, probably due to variation of species adaptation to different agroecologies and human

disturbance [33]. Thus, high IVI confirmed the potential of these species to adapt to an area and to resist anthropogenic disturbance [33].

Floristic composition, distribution and diversity of underutilized edible plants

A good number of UWEs (33 species) were recorded compared to other areas in the Amhara region [8]. These UWEs include trees, shrubs and herbs. Most UWEs were also documented elsewhere in Ethiopia; for instance, seven species are found in the semi-arid lowlands of southern Ethiopia [3,7], species in Derashe and Kucha, southern Ethiopia [7,20], species in Amhara region, northern Ethiopia (8); 20 species in northern Ethiopia; eight species in southeastern Ethiopia; five species in eastern Ethiopia; six species in southeastern Ethiopia [10]. The existence of these plants in different regions of the country indicates their ecological adaptation over a large geographical area and their edibility by different ethnic groups.

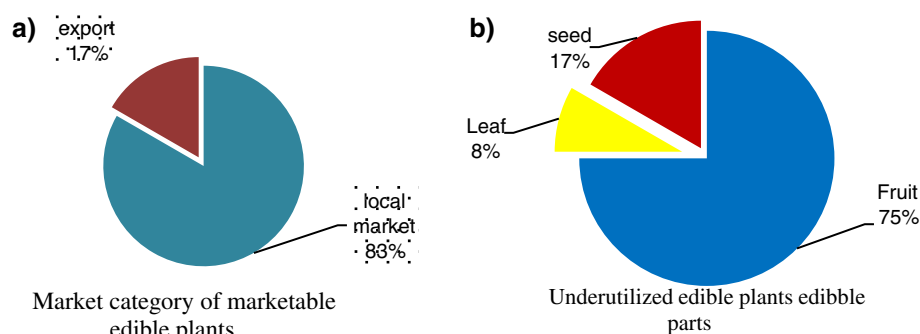


Figure 4 Market categories of marketable edible plants (a) and parts sold (b) in the Chilga District, northwestern Ethiopia.

Table 12 Direct matrix average score of seven underutilized edible plants in lowland agroecology (LLA) in northwestern Ethiopia

| Species | Use category | | | | | | | | Total | Rank |
|--------------------------------|--------------|-----------|---------|--------------|-------|-----------|---------------------|--------|-------|------|
| | Food | Fuel wood | Fencing | Construction | Shade | Medicinal | Home and farm tools | Timber | | |
| <i>Diospyros mespiliformis</i> | 5 | 3 | 2 | 4 | 3 | 0 | 2 | 2 | 20 | 1 |
| <i>Syzygium guineense</i> | 5 | 4 | 2 | 2 | 2 | 1 | 0 | 1 | 17 | 2 |
| <i>Tamarindus indica</i> | 5 | 4 | 2 | 2 | 2 | 0 | 2 | 1 | 17 | 2 |
| <i>Diospyros abyssinica</i> | 5 | 4 | 2 | 3 | 1 | 0 | 1 | 1 | 16 | 3 |
| <i>Ziziphus spina-christii</i> | 4 | 3 | 4 | 2 | 1 | 1 | 1 | 1 | 16 | 3 |
| <i>Ximenia Americana</i> | 5 | 4 | 3 | 0 | 0 | 2 | 2 | 0 | 15 | 4 |
| <i>Carisa spinarum</i> | 4 | 2 | 2 | 0 | 0 | 5 | 1 | 0 | 15 | 4 |
| Total | 33 | 24 | 18 | 13 | 9 | 8 | 7 | 5 | | |
| Rank | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | |

Natural forests, riverine areas and farmlands were centers for UWEPS in the study sites in both MLA and LLA. Similar to this study UWEPS in other parts of Ethiopia were concentrated in farmlands, riverine areas and natural forests [7,8,10,33]. Forests of the world provide livelihoods and food for 300 million people in the form of non-timber forest products [34]. Again, their distributions in different agroecologies vary due to differences in species' physiological adaptations [7].

The study shows almost the same species richness among land uses. As Fentahun and Hager [8] explained, the species richness of wild edible plants is affected by altitude, personal preference and selective management of trees by farmers, especially for those found on farmlands. The Shannon diversity of land uses in both agroecologies is greater than 1.5. Thus, high diversity exists in both agroecologies. Significant differences among kebeles might be due to variation in the levels of human disturbance.

Utilization and socioeconomic implication

Trees, followed by shrubs, were the dominant growth forms of UWEPS in the study area. Although relatively

small in number, herbaceous plants were also consumed. The report by Fentahun and Hager [8] in the Amhara region and in Tilahun and Mirutse [9] in the lower river valley of Debub Omo Zone was consistent with the present finding that trees were the leading growth forms. In contrast, Ermias *et al.* [13] indicated that shrubs were the dominant growth forms in Ethiopia, followed by trees, herbs and climbers. Fruits were the commonly utilized edible parts in the study area. In agreement with this finding, Ermias *et al.* [13] and Getachew *et al.* [35] found fruits as the widely used parts.

The results of this study indicate that UWEPS are used mainly to supplement staple food, to fill food gaps and for refreshment purposes. In agreement with the present study, other findings elsewhere [5,36,37] indicate their supplemental role. The greater number of plant citations by the poorest community in the study area indicates the consumption level and familiarity of the community with these plants. Seasonal food shortages, when household stocks were empty and the new crop was still in the field, were common times to focus on collecting, selling and consuming underutilized edible

Table 13 Direct matrix average score of five underutilized edible plants in midland agroecology (MLA) in northwestern Ethiopia

| Use category | <i>Syzygium guineense</i> | <i>Diospyros abyssinica</i> | <i>Ximenia americana</i> | <i>Mimusops kummel</i> | <i>Carissa spinarum</i> | Total | Rank |
|---------------------|---------------------------|-----------------------------|--------------------------|------------------------|-------------------------|-------|------|
| Food | 5 | 4 | 5 | 5 | 4 | 23 | 1 |
| Fuel Wood | 4 | 4 | 4 | 4 | 3 | 18 | 2 |
| Construction | 3 | 4 | 3 | 3 | 0 | 12 | 3 |
| Fencing | 2 | 3 | 2 | 2 | 2 | 11 | 4 |
| Shade | 2 | 2 | 2 | 2 | 0 | 9 | 5 |
| Medicinal | 1 | 0 | 0 | 0 | 5 | 6 | 6 |
| Home and Farm Tools | 0 | 1 | 1 | 1 | 1 | 3 | 7 |
| Timber | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Total | 17 | 17 | 16 | 16 | 14 | | |
| Rank | 1 | 1 | 2 | 2 | 3 | | |

Table 14 List of frequently cited edible plants in the study sites, northwestern Ethiopia

| Edible species | Walideba | Chalia Debire | Quavier Lomiye | Tenbera | Total |
|--------------------------------|----------|---------------|----------------|---------|-------|
| <i>Syzygium guineense</i> | 23 | 24 | 16 | 17 | 80 |
| <i>Carissa spinarum</i> | 20 | 20 | 19 | 17 | 76 |
| <i>Diospyros abyssinica</i> | 22 | 19 | 15 | 17 | 73 |
| <i>Diospyros mespiliformis</i> | 23 | 2 | 24 | 21 | 70 |
| <i>Ximenia Americana</i> | 11 | 21 | 18 | 18 | 68 |
| <i>Mimusops kummel</i> | 23 | 24 | 8 | 12 | 67 |
| <i>Cordia africana</i> | 19 | 22 | 7 | 15 | 63 |
| <i>Ficus sycomorus</i> | 12 | 13 | 17 | 11 | 53 |
| <i>Saba comorensis</i> | 2 | 14 | 22 | 14 | 52 |
| <i>Ficus sur</i> | 17 | 16 | 6 | 12 | 51 |
| <i>Balanites aegyptiaca</i> | 16 | 2 | 8 | 17 | 43 |
| <i>Dioscorea prahensis</i> | 5 | 20 | 7 | 9 | 41 |
| <i>Ziziphus spina-christi</i> | 6 | 1 | 19 | 11 | 37 |
| <i>Tamarindus indica</i> | 0 | 0 | 19 | 10 | 29 |

plants [36,38]. Marginalized and poor communities are more vulnerable to drought, and thus, are more dependent on these plants [13,34,38,39].

The rural communities of this study, especially the lowland kebeles, preferred *Corchorus olitorius* more than other vegetables because they believe it has more nutritional value. Debela *et al.* [5] also reports on the nutritional richness of this plant. Thus, local people in the

study area bypass nutritional insecurity by consuming UWEs. Some species that were preferable in the study area (for example, *T. indica*, *S. comorensis* and *C. spinarum*) are also priority ranked species in Kenya [40].

Once more, most of UWEs provide service in addition to food value. Different researchers elsewhere in Ethiopia have also noted multiple uses for UWEs such as preparation of remedies, fuel wood, fencing, construction

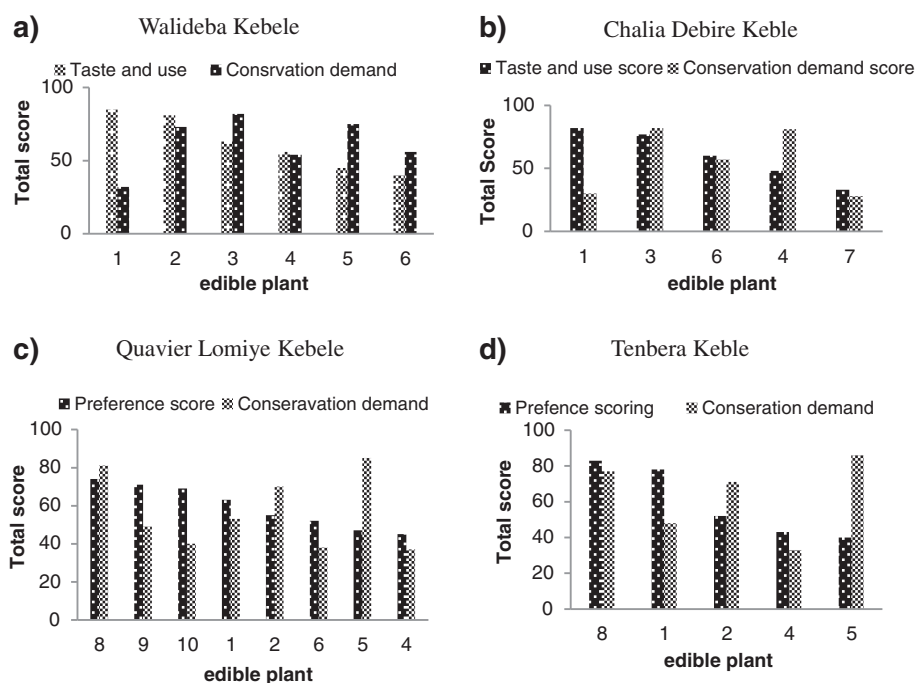


Figure 5 Preference ranking of edible plants in the study sites in the Chilga district, northwestern Ethiopia. Legend: 1 = *Syzygium guineense*; 2 = *Diospyros mespiliformis*; 3 = *Mimusops kummel*; 4 = *Diospyros abyssinica*; 5 = *Ximenia americana*; 6 = *Carissa spinarum*; 7 = *Cordia Africana*; 8 = *Saba comorensis*; 9 = *Corchorus olitorius*; 10 = *Tamarindus indica*.

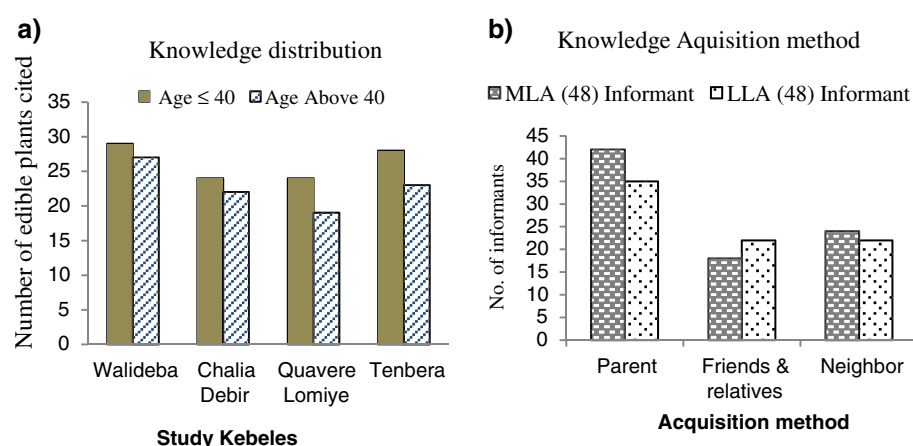


Figure 6 Knowledge distribution and acquisition methods of edible plant in the Chilga District, northwestern Ethiopia.

and timber, farm and household implements and livestock fodder [7-9]. Marketable wild edible plants such as *X. americana*, *S. guineense*, *T. indica*, *C. spinarum* and *M. kummel* also create household income opportunities. A few income-generating species like *S. guineense*, *T. indica*, *C. spinarum* and *M. kummel* were also reported in other areas [7,8]. Furthermore, income is gained from selling other parts such as stems and branches [3,7]. *C. Africana*, for instance, one of the most widely used edible plants in the study area, is preferred for timber production.

According to Bharucha and Pretty [34], there is no comprehensive global estimate of the economic value of UWEPS; therefore, quantitative analyses face methodological difficulties. For most studies, use of different valuation methods and diversity scales are rarely equivalent. Second, the sale of products is often illegal and therefore under-reported. This was observed in the study areas where various UWEPS plants sold at local market and even exported to Sudan were not valued correctly.

Knowledge distribution of underutilized edible plants

Ethnobotanical knowledge and practice within any culture varies depending on such factors as cultural attributes. In a free-list exercise, the differences in list length and content are measures of intraspecific cultural variation [41]. Younger respondents cited a higher number of UWEPS than elders in each study site. Fentahun and

Hager [8] also reported similar results, as younger respondents cited higher numbers than elders did. This might be because of the variation of informant's consumption preferences between adults and youngsters. Adults avoid eating most UWEPS because consumption of wild food plants is seen as a sign of poverty [42]. As a result, their list might be limited to only those species that they are accustomed to eating rather than what they know to be edible. The knowledge acquisition methods (parents are the major source) also proved the ignorance of some species by adults. In addition, younger people had an intimate association with plants in their day-to-day lives and had more experience with collection than the older people [8,43]. A lack of modern training in the study area is also an indicator of the acquisition of knowledge by experience and the effect of their interaction with plants in their daily life.

Table 16 Traditional management practices and threats of underutilized edible plants in the Chilga District, northwestern Ethiopia

| CSI | LLA (48) | | MLA (48) | |
|--|------------|------|------------|------|
| | Informants | % | Informants | % |
| Management practices | | | | |
| Planting around home garden | 9 | 18.8 | 18 | 37.5 |
| Pruning | 8 | 16.7 | 9 | 18.8 |
| Pollarding | 10 | 20.8 | 14 | 29.2 |
| Fencing | 10 | 20.8 | 11 | 22.9 |
| Protected by culture | 12 | 25 | 11 | 22.9 |
| Threats | | | | |
| Agricultural expansion | 32 | 66.7 | 21 | 43.8 |
| Construction | 26 | 54.2 | 37 | 77.1 |
| Fuel wood collection and charcoal making | 32 | 66.7 | 40 | 83.3 |
| Overgrazing | 23 | 47.9 | 19 | 39.6 |
| Fire | 11 | 22.9 | 0 | 0 |

Table 15 Response of households on training gained about conservation and utilization of underutilized edible plants in the Chilga District, northwestern Ethiopia

| Response | MLA (n = 48) | | LLA (n = 48) | |
|----------|--------------|------|--------------|------|
| | Informants | % | Informants | % |
| Yes | 11 | 22.9 | 6 | 12.5 |
| No | 37 | 77.1 | 42 | 87.5 |
| Total | 48 | 100 | 48 | 100 |

Management practices and threats to underutilized edible plants

The farmers in the study area apply some management activities like pruning and pollarding for UWEs in farmland use. In addition, the farmers plant some plants in their front yards and backyards. However, compared to other cultivated plants, the management practices were very small. The study by Fentahu and Hager [8] in other semi-arid areas of the Amhara region similarly depicted a lower level of management, and if any, limited to lopping and pollarding.

The threats to UWEs in the study area are similar to threats that affect nonedible wild plants. Agricultural expansion, overgrazing, fire and other utilization-related factors such as fuel wood and charcoal, construction, and house and farm implements are the major threats in both agroecologies. Different researchers have documented these threats [3,7,13,38] to UWEs. Furthermore, UWEs are collected in natural environments, which are subjected to less management and exposed to anthropogenic threats [13].

Conclusions and recommendations

The Chilga District, located in the Amhara region, northwestern Ethiopia is endowed with diverse UWEs and ethnobotanical knowledge. Thirty-three UWEs (22 families) were recorded. These plants are distributed in natural forests, riverine forests and farmlands.

UWEs are consumed for supplementing staple food, filling food gaps and recreational value. This utilization is significant in the poorest communities. Most of the encountered UWEs provide other services including medicinal value, fuel wood and charcoal, construction, timber, and farm and household implements, thereby generating income from the sale of the products and their parts. Thus, UWEs are the solution to diversification of rural household livelihoods. The utilization of some UWEs (such as *S. guineense*, *D. abyssinica*, *C. spinarum*, *M. kummel*, *D. mesiliformis*, *X. americana* and *C. africana*) is more popular than for others.

UWEs are suffering from the threats of agricultural expansion, overharvesting (for fuel wood, construction, and fencing) and overgrazing in both agroecologies. However, the management activities are also lower.

The local community utilizes UWEs without gaining organized training, which is a threat to the sustainability of these plants. Thus, provision of training from the district, zonal offices, and NGOs for different management activities and the application of this training to projects that seek to maximize the value of UWEs to local community are needed. This study focuses on diversity, role, threats and associated plant-use knowledge. Further study on the nutritional analysis and economic valuation of UWEs is needed.

Additional file

Additional file 1: Importance value index of plants.

Abbreviations

FL: farmland; HH: household; IVA: importance value index; KA: kebele; KI: key informants; LLA: lowland agroecology; LSd: least significance difference; m.a.s.l.: meters above sea level; MLA: midland agroecology; NF: natural Forest; R: riverine forest; UWE: underutilized wild edible woody plant.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MT: conception and design, data collection and analysis, manuscript writing and final approval of the manuscript. ZA: data analysis, critical revision and final approval of the manuscript. SZ: critical revision and final approval of the manuscript. All authors read and approved the final manuscript.

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Author details

¹Department of Natural Resource Management, University of Gondar, P.O. Box 196, Gondar, Ethiopia. ²School of Forestry, Wondo Genet College of Forestry and Natural Resources, Hawassa University, P.O. Box 128, Shashemene, Hawassa, Ethiopia. ³Department of Biology, Addis Ababa Science and Technology University, Addis Ababa, Ethiopia.

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